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ABSTRACT

Designed to aid in making concrete decisions on the acquisition and use of media, the criteria system and evaluation procedure described is a multiphase, objective-based decision making process. This report includes guidelines for setting up goal systems and developing criteria for the evaluation of media based on a goal system; an outline of various methods for comparing alternatives and checking them for their conceptual and practical efficiency; a description of multi-criteria utility analysis (MCUA), a method that permits multi-dimensional treatment of a problem and is particularly suitable for evaluating technological educational media; and an example of the use of MCUA for evaluating audiovisual media. Supportive figures and tables, a glossary of terms, and a bibliography of 35 items are provided. (CHC)

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February 1979

PRACTICAL GUIDE FOR THE SELECTION OF AUDIO VISUAL MEDIA

GENERAL CRITERIA SYSTEM AND EVALUATION PROCEDURE FOR EDUCATIONAL MEDIA DECISIONS

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INTRODUCTION

In recent years, far-reaching innovations have been made in the curricular content of education in many countries. In this conncection, questions of media equipment in schools have come to the fore and it has become clear that, at the operative level (the individual school), the material requirements necessary to implement the innovative curricular framework concepts often have been lacking (cf. e.g., Brauner/Weiss/Mirgel, 1979).

In the process of adapting the equipment situation to fit the altered conditions, it has become manifestly apparent that there is a lack of appropriate decision aids. For one thing, there are, in general, no requirement profiles - drawn up on the basis of careful curriculum analysis - in the form of differentiated standard equipment catalogues, to which the individual educational institution could refer in order to determine its media requirements. For another, there are no detailed and systematically compiled criteria catalogues for media evaluation and selection to aid in the preparation of concrete decisions on the acquirement and use of media.

The latter problem area is the subject of this report which is focussed on the presentation of a criteria system and evaluation procedure to meet the requirements of multidimensional media evaluation.

In the first section of Part I (1.1) the process of media acquisition and use is described - on the basis of a general decision-making model - as a multiphase, objective-based decision-making process. Within this process, especial significance attaches to the media evaluation phase. As experience shows, rational decision-making is made particularly difficult by the lack, at this stage of decision preparation, of a structured and comprehensive goal system for the identification of evaluation criteria. The next paragraphs of Part I deal with this set of problems. Section 1.2. gives some general methodological advice on setting up goal systems and arriving at evaluation criteria on the basis of which a goal system for media evaluation is finally presented and its content discussed. A few notes on the practical application of the goal system conclude Part I.

In connection with the application of this goal system as a basis for the evaluation and selection of alternative AV media, the problem arises of how to amalgamate the various types of data into an overall expression of the advantageousness of each alternative. This is necessary in order to be able to make a rational comparison of alternatives and to select the most favourable. With regard to this aspect, the first section of Part II begins by outlining various methods for comparing alternatives and - with reference to the field of application with which we are concerned - checking them for their conceptual

and practical efficiency (2.1). There follows a description of multi-criteria utility analysis, a method that permits multi-dimensional treatment of a problem and which is, therefore particularly suitable for evaluating technological educdtional media (2.2). The procedure for this method is illustrated by an evaluation example in the final part of the study (Part III).

1. Evaluation and selection criteria for the acquisition and use of AV media (1)

1.1. Media acquisition and use as a decision-making process

1.1.1. General phases of decision-making processes.

Every decision-making process can, in principle, be regarded as consisting of various phases that may be described as problem formulation, search for alternative possible solutions, evaluation of alternatives and the decision itself (similar structures are proposed, for example, by Newman/Summer/Warren, 1972 and Simon, 1977). The first three phases complete the stage of decision preparation and the whole decision-making process comes to an end with the taking of the decision itself. This leads on to the implementation or execution of the decision (realisation) and, in some cases, to the monitoring of results (see Fig. 1.).

The reason for taking a decision is always the presence of a problem. A problem is generally characterised by the fact that there is a discrepancy between the existing state of affairs and the desired state of affairs. Usually, there are several possibilities that may be considered for bringing about the intended change in a given situation and thest must first of all be identified. The decision itself then consists in picking the "most favourable" of the alternatives qualifying for consideration. To do this, the individual alternatives have to be evaluated, compared and placed in an order ofr preference. The decision-relevant effects (outcome) of the individual alternatives provide the basis for their selection. Decision-relevant outcomes are those which concern:

i) certain (or all) of the criteria in the goal system of the decision-maker, and

ii) contextual factors over which the decision-maker has no influence.

In order to arrive at a rational decision, only these two categories of outcomes have to be considered out of the many conceivable effects that the alternatives might have. In principle, any alternatives that are incompatible with the decision-relevant contextual conditions cannot be considered; in other words, only the permissible alternatives should reach the evaluation phase. Evaluation is then a matter of the

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(1) By AV media is meant non-personal technical media which transmit information audio-visually. In combination with computers, these media can, in principle, be used in the framework of the C.A.I.

decision-maker expressing his relative preference for the outcomes of each alternative. If all the criteria relevant to the decision situation are explicitly taken into account in the evaluation then an order of preference for the alternatives is arrived at for each criterion. At this point, in order to be able to decide which alternative is to be preferred, it is necessary to amalgamate the individual scores obtained for each goal criterion into one single index per alternative (for more detail see 2.2.1.6).

1.1.2. Problems of the evaluation phase

For rational decision making, the evaluation phase - the subject of the following paragraphs - is of vital importance particularly in those problem-solving situations which - as in the case of media selection - exhibit the following features:

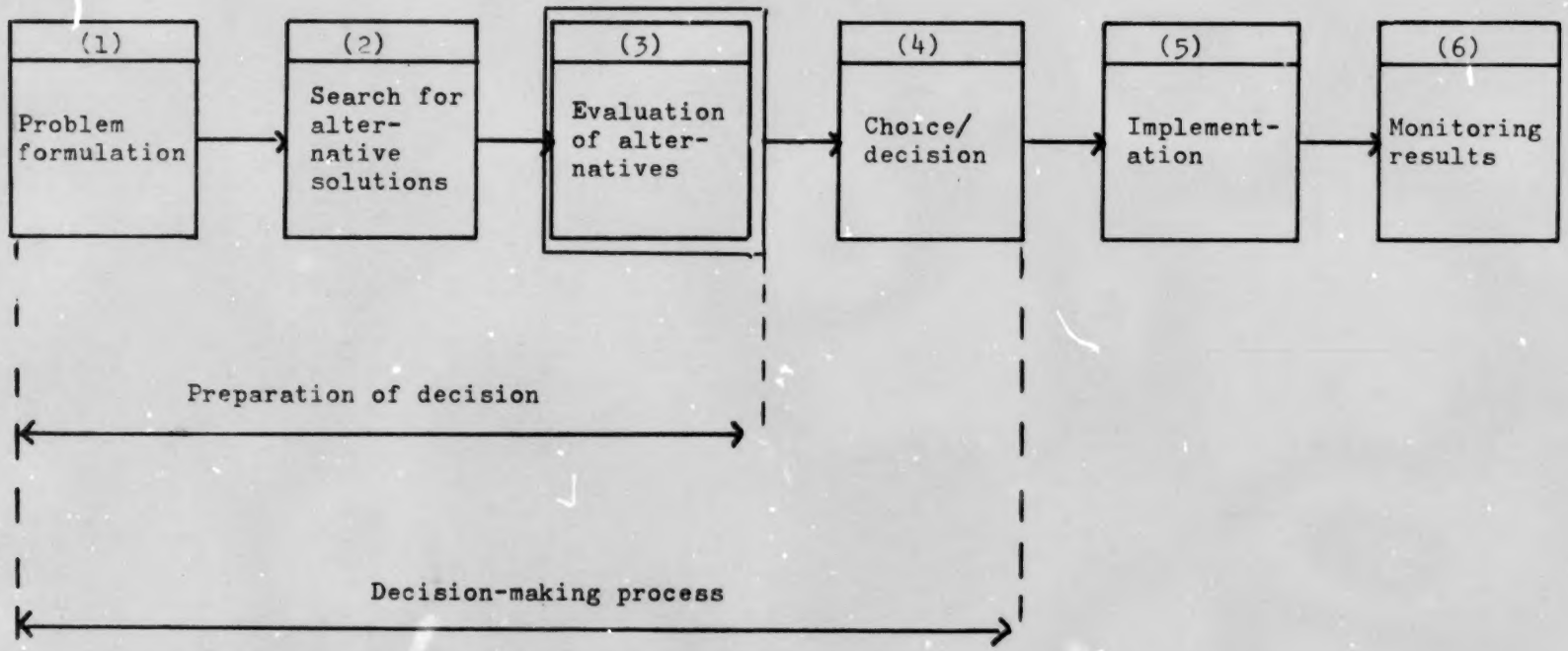
- several alternatives have to be compared with one another,
- a large number of decision-relevant criteria have to be considered, and
- the decision-maker attaches differing relative importance to the individual criteria.

In complex problem-solving situations, as experience shows, the evaluation phase is often the Achilles heel of the decison-making process. There are two main reasons for this:

i) The use of inadequate evaluation and selection procedures. In practice, alternatives are, for the most part, compared on the basis of one-dimensional or limitedly multi-dimensional procedures (cf. 2.1). This generally implies that the complexity of real decision situations is unacceptably reduced to the extent that only those aspects with which the method can cope are taken into account. Rational decision-making, however, generally requires multi-dimensional evaluation and therefore an evaluation method allowing the logically satisfactory amalgamation of all the decision-relevant outcomes of an alternative into an overall value of its advantageousness.

ii) The lack of an appropriate reference basis in the form of a structured and harmonized goal system that can be used for the systematic derivation of evaluation criteria. The result is often that important aspects are left out of account and/or decision-irrelevant aspects, or even mutually-exclusive criteria, find their way into the evaluation process.

Fig. 1. General phase structure of decision-making processes



With regard to the problem of an appropriate evaluation method, an efficient technique from both the conceptual and practical angles is available through multi-criteria utility analysis. A full description of the methodology of this technique is given in Part 2 of the report and its possible application in the evaluation of AV media illustrated by a concrete example.

Concerning the second problem area, which is related to the content components of the evaluation phase, Klepzig (1976) reaches the conclusion, on the basis of a thorough analysis of the literature, that the criteria catalogues so far used for ecaluating AV mnedia as a basis for preparing decisions on media acquisition and use are inadequate because they neglect certain essential aspects - in particular, certain relevant contextual factors - and that they are the result of a systematic process of deduction in only very few cases. The majority are single-discipline, aspect-oriented partial-approaches to media evaluation; at the moment there are no comprehensive, multi-disciplinary approaches.

Detailed and systematic criteria catalogues are occasionally available for individual evaluation aspects. Firstly, there are the catalogues that have been developed for cost analysis and cost comparison (cf. the list in Orivel, 1977) and secondly, there are the criteria tables produced in the context of research on teaching for evaluating the suitability of media in terms of their performance of certain instructional tasks. From these, various media classifications have been developed designed to simplify media selection in instructional planning. Gagné (1971), for instance, proposes a classification scheme in which media and instructional functions are related to one another. A similar classification scheme showing the suitability of various media for achieving specific learning objectives, is given by Allen (1967). Tosti and Ball (1969) select kind of stimulus, period of presentation and kind of reaction as classification criteria. The scheme suggested by Briggs (1970) is based on learner characteristics, task requirements and aspects of the materials used and of media transmission as classification criteria.

These classification schemes are of limited value even for planning the use of media in instruction (see reasons given by Heidt, 1975), but this is all the more true for the acquisition of media. This calls for a more comprehensive catalogue of criteria since - among other things - technical and financial aspects and school organisation problems have to be taken into account, which have little if any importance in planning the instructional use of media.

The purpose of the following paragraphs is to draw up a catalogue of media evaluation criteria embracing all the essential aspects that could have any significance in the acquisition and use of AV media. The presentation of this catalogue and the commentary on it are preceded by a discussion of the methodology used in drawing up these criteria.

1.2. Goal system for the evaluation of AV media

1.2.1. Construction of a goal system

On the assumption that the evaluation is to serve the purposes of a reasoned and logical choice, then the relevant objectives in the particular decision situation are decisive for the selection of evaluation criteria and these goals, which determine the method, must first be identified. In complex decision situations it is advisable to use a systematic search technique in order to make sure that the essential evaluation criteria are fully covered. The basis for this is an overall goal - generally expressed verbally - which has to be converted into sub-goals by systematic stepwise breakdown. Here, care must be taken to see that the sub-goals at any given level fully cover the next direct goal above, so that the latter is attained if the sub-goals are attained. The goals at the lowest level of the goal system represent the criteria on which evaluation has to be based. These criteria must be formulated in operational terms so that the goal relevant effects of the alternatives can be clearly assessed. A goal criterion is operational if :

- the substance of the goal is defined, in other words the goal has to be described in terms of the essential characteristics in the particular decision situation;
- the goal outcome is fixed in terms of its individual dimensions. In particular, the extent to which a given goal has to be attained, and at what point of time, have to be stated.

Apart from the requirement that the criteria have to be operational, special attention has to be paid to the horizontal relationships between the individual criteria at each level of the goal system. These relationships can be differentiated in terms of the way in which a change in the intensity (degree of attainment) of one criterion affects the intensity of another. In the main, a distinction can be drawn between the following horizontal relationships:

- goal complementarity (goal harmony) : as the degree of attainment of one criterion increases so does that of another;
- goal neutrality (goal indifference) : the attainment of one criterion has no effect on that of another;
- goal incompatibility (goal competition) : as the degree of attainment of one criterion increases, that of another decreases.

As far as possible, the goal system should include only those goal criteria to which the principle of goal neutrality

applies. In practice, this ideal goal system is hardly possible.

Where there is a high degree of goal complementarity, it is proposed that only one of the complementary criteria should be used for the evaluation in order to avoid too great an influence being exerted by one and the same goal aspect. Goal incompatibilities can be allowed for by setting the desired minimum and/or maximum intensities for the criteria. Incompatibility between two criteria then presents no problems if the minimum limit at least is reached and the maximum limit not exceeded. If this is not the case, in other words, if there is a high degree of competition between two criteria, then a check should be made to see whether these criteria are in harmony with one of their common goals at the higher level - particularly the overall goal. If so, then the incompatibility is justifiable, but, if not, one of the incomptable criteria has to be elimiated from the goal system. The remaining relationships between the criteria can be taken into consideration at the goal weighting stage (cf. 2.2.1.5)

The definitive formulation of a goal system can be carried out only in relation to a specific and concrete decision situation. That means that incompatibilities - apart from contradictions to definition logic - can be investigated only in relation to quite specific decision situations.

1.2.2. Development of a goal system for media evaluation

At the end of the last section it was stressed that the formulation of a goal system could be finalised only in terms of a concrete decision situation and, therefore, the goal system for the evaluation of AV media presented below is not intended to provide a universally applicable collection of goal criteria. It is more a comprehensive and systematically structured list of goal criteria which should be complete at least in terms of the defined criteria framework. Other goal criteria can be derived from this list for the construction of a concrete goal system applicable to the practical use of AV media.

The establishment of a goal system is based on the primary goal of "Optimum media selection" in terms of the subordinate goal criteria of:

- expenditure
- characteristics of utilisation
- organisational feasibility.

"Expenditure" covers the largely deterministic parameters and directly quantifiable data with regard to:

- dates and timings, and
- cost criteria

The different cost criteria can generally be lumped together in a single cost index such as "Cost per addressee per hour".

"Characteristics of utilisation" covers, under "performance", the stochastic parameters of AV media and their effects and, under "capability" those media properties that are largely incapable of any direct quantitative definition,

"Organisational feasibility" covers both in-school and extra-mural criteria.

These criteria are then further broken down in accordance with the time phases through which the media system passes as follows:

- Preparation for the introduction or adaptation of and AV media system
- Production and recording of the subject matter and its transcription onto the programme medium
- Storage and reproduction of the programme medium
- Conveyance of reproduced programme medium to the playback location
- Playback
- Adaptation

The criteria to be included in the catalogue are essentially pragmatic and formulated without any further deduction, existing criteria collections (in manufacturers' catalogues, for example) being sifted, analysed and incorporated. The catalogue should also include the findings of the behavioural sciences so long as these produce generally accepted and operational criteria.

Particularly important here are the conditions of specific reinforcement, contiguity and practice, which - from the standpoint of educational psychology - may help to optimise the teaching process and to arrive at the optimum choice of media (cf. e.g. Gagné, 1971). It is also important that the student should work through the material with undertstanding. A further important condition is the activity of the receiver during the learning process (cf. e.g. Hilgard/Bower 1966) (2)

For the choice of work periods a distinction has to be made between voluntary and imposed learning rhythms. The question of which is preferable has to be decided in relation to each specific case. Freedom to pick one's own time to participate in education may, in principle, be just as

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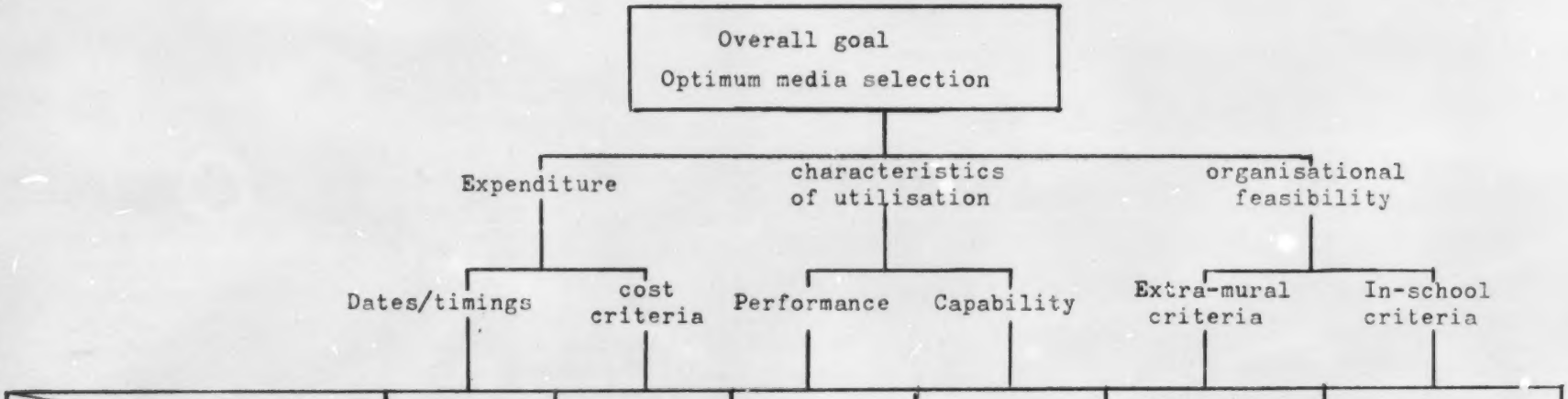
(2) Programmed instruction, which can also be given via AV media, is a particular form of education fulfilling the conditions that are mentioned.

advantageous as the compulsion of an imposed rhythm of learning (cf. e.g. Schramm, 1973). The same applies to the speed of learning. If imposed from outside it may serve as a pacemaker but it may also make too great a demand on the student (cf. e.g. Hofer, 1973)

The use of colour in educational AV media has no general advantage over black and white in cognitive learning objectives unless particularly important information in the subject matter otherwise reproduced in black and white needs to be brought out by the use of colour, or the colour presentation is itself significant (cf. Dwyer 1971; Katzman/Nyenhuis, 1972). Conversely, it would appear that colour reproduction has a more emotional effect on students than black and white (cf. e.g. Kanner, 1968).

These behavioural science considerations need to be tested for their significance in practical media evaluation situations and are taken into account in the following criteria catalogue.



phases \ criteria	A	B	C	D	E	F
1. Preparation						
2. Production/recording						
3. Storage/reproduction						
4. Conveyance						
5. Playback						
6. Adaptation						

Table 1. Goal system for AV media evaluation (general view) Developed presentation for each criterion are shown on the following pages.

Criterion A

Dates - timing

A.1.	Preparation	- Term of delivery
		- Length of internal preparation
		  - familiarisation of teaching, operating and maintenance staff
		  - preparations as regards space
		  - installation

A.2.	Production/ recording	- Time elapsing between placing of order and delivery of original programme medium
		  - period for producing subject matter
		  - corrections
		  - period for producing the programme medium ready for reproduction

A.3.	Storage/ reproduction	- Time for copying and reproduction
A.4.	Conveyance	- Time for conveyance/shipment of programme medium from copying and reproduction service to user and from user to addressee

A.6.	Adaptation	- Time for adaptation
		(for "one-off" adaptation, inter alia:
		Time elapsing between awareness of need for adaptation and completion of adaptation.
		In the case of "regular" adaptation, inter alia: period for which the system or parts of the system are not available for education)
		  - changes to subject matter
		  - changes to equipment

Table 1a - Goal system for AV media evaluation - detailed presentation criterion A

Criterion B

Costs

B.1. Preparation

- "one-off" costs

  - Equipment costs
    - Accessories
    - Transport costs
    - Conversion costs/installation
    - Tests
  - Premises costs
    - Structural changes
    - Storage accommodation
    - Fittings and accessories
  - AV materials
    - Programme media costs
    - Other materials
  - Staff costs
    - Consultants
    - Preparatory investigations/ comparative calculations

B.2. Production/ recording

    - Authors' costs (production of new and revision of existing subject matter)
    - Instruction of operating and maintenance staff

B.3. Storage/ reproduction

    - Pretesting curricula

- Running costs

B.4. Conveyance

  - Equipment costs
    - Rental/depreciation for recording, copying, reproducing and playback equipment and accessories

B.5. Playback

    - Maintenance and repair
    - Insurance
  - Premises costs
    - Premises and energy costs for equipment, audience, storage and staff
  - AV materials costs
    - Wear and tear for regular production work on subject matter
    - Other materials costs
  - Staff costs
    - Regular salaries, teaching, operating and maintenance staff
    - Regular salaries of trainees
    - Regular instruction of teaching, operating and maintenance staff
    - Care of materials, corrections, ecaluation documentation
    - Regular production of subject matter

B.6. Adaptation

- Subject matter
- Equipment

Table 1b - goal system for AV media evaluation detailed presentation criterion B

Criterion C

Performance

C.2. Production/ recording
- Availability of recording equipment

C.3. Storage/ reproduction
- Availability of copying and reproducing equipment

C.5. Playback
- Availability for use
  - Reliability
    - Wear/lifetime of programme media and playback unit
    - Stability of programme media (heat/colour/stability/ dirtying)
  - Maintainability
    - Simplicity of maintenance for parts subject to wear
    - Problems of adjustment (adjustment at works/by after-sales service/by operating staff)
  - Availability of spares
    - Service conditions (maximum waiting time/efficiency of after sales service)
  - Alternative reproduction possibilities
    - In-school/extra mural possibilities

Table 1c - goal system for AV media evaluation
detailed presentation of criterion C

Criterion D

Capability

D.2. Production/ recording

- Possibilities/requirements as regards self-production of curriculum/self-recording
  - Convenience to authors
  - Convenient to users

D.3. Storage/ reproduction

- Programme media criteria
  - Spread (national/international)
  - Compatibility/standards questions
  - Suitability for shipment and conveyance
  - Deletion/re-recording
  - Reproduction requirements (methods for reproducing in single copies or large quantity)
  - Maximum duration per media unit

D.5. Playback

- General playback criteria
  - Familiarity with the medium
  - Spectrum of use (performance/ programmed education)
  - Geographical mobility
  - Possibilities of social interaction
- Presentation
- Quality of presentation
  - Sound and picture quality
  - Still or moving pictures
  - Colour/black and white
  - Reduction/enlargement
  - Slow motion
  - Largescale projection
  - Blackout requirements
  - Noise made by equipment
- Possibilities for individual or group teaching
- Facility of operation (Cassettes/automatic threading, etc)
- Abilities required of addressees
  - Ability to read
  - Colour recognition
- Individualising possibilities
  - Learning speed (governed by programme, teacher or student)
  - Learning rhythm (imposed or not, "time mobility")

Table 1d goal system for AV media evaluation
detailed presentation of criterion D

20

continued ...

criterion D

- Answer
  - Types of answer (free answer/multiple-choice/ verbal input)
  - Answer possibilities/abilities required of addressees
    - keyboard/manuscript
- Checking
  - Evaluation
    - Evaluation by programme/ teacher/student
  - Instruction for next learning unit
    - Contiguity/average waiting time/ random access
    - Compulsory activity
    - Specific practice
    - Specific reinforcement
    - Next learning step decided by programme/teacher/student
    - Possibility of repeating, including retrival of past subject matter
    - Check on whether student is learning with understanding
    - Initiative for transfer

D,6. Adaptation

- Flexibility (adaptability to changing requirements)
  - Reserve capacity of hardware with regard to number of addressees
  - Extendibility of hardware
  - Interchangeability of elements of the media system with regard to systems coming into use at a later date
  - Suitability for integration with other media
  - Adaptability to broader fields of application (i.e. universal/ special equipment)
- Compatibility
- Adaptability of subject matter
  - Centralised modification possible/ individual programme media have to be modified
  - Interchange of curricular units possible/not possible on the modular principle

Table 1 d bis

Criterion E

Extra-mural criteria

E.1.	Preparation	- Criteria with regard to manufacturers
		  - Image of manufacturer/opinion of earlier customers
		  - Experience of manufacturer
		  - Popularity of equipment
		  - Present and future level of development of equipment
		  - Support from manufacturer during preparation
		  - Contractual conditions, including guarantee
		- Nature and extent of hardware-related supply of course units (on the part of the manufacturer/ curriculum centres/other users)

E.2.	Production/ recording	- Support from manufacturer in production
E.3.	Storage/ reproduction	- Conditions/possibilities of extra-mural/in-school reproduction (e.g. copyright questions)
E.6.	Adaptation	- Situation and trends in the used equipment market

Table 1e : goal system for AV media evaluation
detailed presented of criterion E

Criterion F

In-school criteria

F.1. Preparation	- Possibilities/difficulties/ bottlenecks as regards meeting demand - Availability of teaching, operating and maintenance staff - Resistence of teaching staff to change to previous system - Further use of existing programmes

Table 1.f : goal system for AV media evaluation
detailed presentation of criterion F

1.2.3. Use of goal system for media evaluation

The criteria catalogue set out in Table 1 is intended to enable the decision maker to establish a complete and structured catalogue containing the essential requirements an AV medium has to fulfill in a specific situation. The first step, in a concrete and practical case, is to select the criteria relevant for media evaluation - taking into account the evailability of the information

Given the way in which the catalogue is broken down by time phases, complete sets of criteria can be discarded if, say, production/recording or reproduction is not an in-school responsibility. The same applies if the medium does not require any special copying or reproduction process.

It may also be necessary to formulate supplementary sub-goals in addition to the evaluation criteria set out in the catalogue. Lastly, the sub-goals on which the evaluation will be based have to be made operational according to the specific situation. If, for example, the geographical mobility criterion is felt to be important, aspects such as

- weight kg
- dimensions m or m^3
- power supply from batteries/storage batteries/mains -

may, in specific cases, be relevant which will then need to be taken into account as sub-goals in the evaluation and made operational.

Although primarily designed for the evaluation of AV media, the criteria catalogue is just as suitable for the evaluation of alternative types of media and instructional methods (e.g. programmed education).

2. Methodological aids to media evaluation and selection

2.1. Survey of methods for the comparison of alternatives

A number of methods may be considered for the solving of evaluation and selection problems differing from each other in various ways. An essential kind of difference, which at the same time throws light on the practical relevance of the method, is the way in which goals and goal outcomes are dealt with. A basic distinction can be made, on the basis of the number of goals considered into one dimensional and multi-dimensional selection techniques.

The one-dimensional methods include, first and foremost, the investment calculation techniques used in private enterprise, developed for assessing the economic advantageousness of "alternative" investment projects. Confined to the monetary effects (revenue and expenditure or profit and costs) they indicate the most favourable project only from the economic point of view. If only one period of time is used then the method is called static investment calculation (e.g. cost or profit comparison); if several periods of time are taken into account, then the calculation method is called dynamic (e.g. net value method, internal rate of return method). In the educational field, cost comparison is generally the only one of these methods that may be concerned in the solution of selection problems because, there being no market proceeds ford the services provided in a public education system, no revenue can be assigned to the investment project. Several cost comparisons of this kind have been made for AV media (cf. Unesco, 1977). The costs arising for the different media over a given period (usually one year) are compared, the comparison yardstick most commonly applied being the "cost per addressee/per hour" index. Although this method has the advantage of providing a relatively simple assessment of the advantageousness of alternative actions, it has to be borne in mind that a correct decision is possible in this way only if - and this is rarely the case - other (non-monetary) criteria are not involved or if the alternatives being investigated differ only with regard to their cost and not in terms of the other decision-relevant aspects.

Mathematical decision models developed in the context of Operations Research can also, to some extent, be included among the one-dimensional methods (see e.g. Cooper/Steinberg, 1970). The specific characteristic of these methods is that effectiveness, related to a quantitatively definable criterion is maximised on the basis of a numerical goal function on the secondary conditions that effectiveness with regard to other decision-relevant criteria does not fall below a given minimum. These models can therefore be included in the category of one-dimensional choice procedures in that they recommend the maximising or one effectiveness. The other goal criteria can be taken into account only in the form of secondary conditions.

Apart from the fact that such methods are often impractical and costly in terms of information gathering and processing it may also be objected that they are based on questionable premises regarding the decision-maker's value system. It is assumed, say in the comparison of two alternatives which both satisfy the required secondary conditions, that a difference in effectiveness, no matter how big, with regard to a goal allowed for by a secondary condition will be attributed less value by the decision-maker than a difference in effectiveness, no matter how small, in relation to the maximisation goal.

Cost-benefit analysis (CBA) was developed as a corollary to the investment calculation techniques used in private enterprise (cf. Prest/Turvey, 1965, Woodhall, 1970, Mishan, 1972, UNIDO, 1972, Wolfe, 1973). The purpose of this method is to try, by simulating a market situation, to bring about a rational allocation of resources in those fields too that have to rely on administered resource allocation. Prest/Turvey (1965) define CBA as "a practical way of assessing the desirability of projects, where it is important to take a long view (in the sense of looking at repercussions. . .) and a wide view (in the sense of allowing for side-effects of many kinds on many persons, industries, regions etc)"

Planned projects are assessed and selected on the basis of their net benefit to the economy as a whole. For this purpose the expected effects of the project are established for a given period of time and - through an evaluation in monetary units converted to "social" costs and benefits made comparable by discounting to a common point in time. However, since in most cases evaluation in monetary units is logical and possible only for part of the effects of a project, CBA can be described as only restrictedly multi-dimensional. It therefore foreshortens the decision problem in such situations where effects arise that cannot be converted to monetary costs and benefits.

In recent years, criticism of CBA has increasingly prompted the development and use of methods that are not tied to the condition of measuring all project effects by a common monetary dimension. An essential characteristic of these methods - knowns as cost-effectiveness analysis (CEA) is that the measurable project effects are used directly (i.e. unevaluated) as a basis for the comparison of alternatives (cf. on CEA: English, 1968, Seiler III, 1969, Carpenter/Haggart, 1970, Goldman, 1971 and Pearson, 1973) There is no explicit amalgamation of the incommensurate outcomes, which is generally possible only by conversion to a standard dimension (monetary units or utility) (cf. e.g. Easton, 1973). Instead, the various outcomes or cost-effectiveness relationships derived thereform are presented to the decision-maker for information. In other words, it is left to him to implicitly evaluate the worth of each alternative (Klees/Wells, 1977). This procedure, although it certainly maintains the primacy of policy decisions, is unsatisfactory because the way in which evaluation has been reached is not apparent to outsiders.

In many cases the amalgamation problem is also avoided by fixing minimum levels for part (or all) of the project outcomes allowed for on the effectiveness side and then selecting out of all the alternatives that meet the minimum conditions, that which involves the lowest cost. As with mathematical decision models, criticism could again be levelled here at the premises regarding the decision-maker's value system implied by the different goal treatment: whereas - on the cost side - all differences, no matter how small, are treated by the decision-maker as significant, on the effectiveness side - since outcomes going beyond the minimum level are left out of account - differences in outcome are treated indifferently regardless of how great they are.

If - as with the problem of media acquisition and use that we are discussing - the decision situation is characterised by the fact that a large number of (partly competing) goal criteria have to be taken into account, those methods are more promising for rational decision-making that apply the utility concept to the evaluation of alternatives. They make it possible to deal with problems on a multi-dimensional and system-oriented basis. The criteria identified as relevant to the decision can be taken into account without limitation and uniform goal treatment is achieved by using "utility" as the common yeardstick. Utility in this case means the subjective value of a measure, project, etc., determined by its usefulness in attain a goal. (Zangemeister, 1970). Evaluation of the laternatives takes place in two stages: Firstly, the outcomes not directly comparable are given the same denominator by converting them to a utility measure, which expresses the individual preference of the decision-maker regarding the outcome. To put the alternatives in an order of preferability, the evaluated outcomes - the (unweighted) partial utilities - are then combined into an overall score for each alternative taking into account the relative importance (i.e. weights) given to the criteria by the decision-maker. This is a broad outline of the media evaluation method that is described in the following chapter.

2.2. Multi-criteria utility analysis (MCUA) as a method for evaluating AV media.

2.2.1. Methodology

MCUA is a method for evaluating alternatives (projects, programmes etc) in complex decision situations. With the help of this method it is possible to evaluate alternatives taking into account not only a multi-dimensional goal system, but also the relative importance of the individual goals and outcomes for the decision-maker (in other words his preference structure), whereby each phase of the evaluation process is fully explicated. The preferability of an alternative is expressed by a utility index determined by a process consisting of several stages, as follows:

(1) Construction of a goal system to determine the decision-relevant evaluation criteria

(2) Preselection of alternatives on the basis of fixed minimum conditions

(3) Description of alternatives in terms of their contribution to the individual criteria (= determination of outcomes)

(4) Partial evaluations of alternatives : conversion of outcomes into unweighted partial utilities (= determination of utility scores)

(5) Weighting of criteria

(6) Amalgamation index: amalgamation of weighted utility scores into a utility index for each alternative.

2.2.1.1. Construction of a goal system

First, it is necessary to determine the decision-relevant goals to put them into an appropriate order and to identify the criteria (= sub-goals of the lowest level of the goal hierarchy) on which the evaluation is to be based (for details see 1.2). The individual criteria then have to be looked at to see whether, and to what extent, there are (horizontal) relationships to other criteria. For this purpose, it is useful to construct a "compatibility matrix" which indicates whether there is goal complementarity, neutrality or incompatibility (see example in Part 3).

2.2.1.2. Preselection of alternatives

When the decision-relevant criteria have been established and subjected to a compatibility test, the next step is to make a preselection from the alternatives which, in principle, qualify for consideration. For this, the desired limits (minimum or maximum intensities) are fixed for individual (or all) criteria (e.g. cost limits) which the alternatives to be evaluated must not go below or above. The setting of these limits ensures that only such alternatives qualify for finer selection that are considered to be at least adequate. Alternatives that do not meet the conditions set are dropped. In this way, the number of alternatives is generally reduced and decision preparation facilitated. From the decision theory angle it is important that, in deciding on minimum conditions, the requirement of utility independence is met since this is important for the making of partial evaluations (cf. 2.2). At the same time, these minimum conditions establish the zero point on the utility scales (cf. 2.2.1.6)

2.2.1.3. Description of alternatives in terms of their contribution to the individual criteria (= determination of outcomes)

In the next step, the intensities of the alternatives under consideration with regard to the individual criteria - the outcomes - have to be determined. For this it is essential that the criteria be clearly defined and a suitable measurement scale (outcome scale) found in each case. This condition is met for criteria such as costs which are formulated in quantitative terms, but an operational description of the intensities of qualitative criteria is generally more difficult. Sometimes, however, it is possible to fall back on auxiliary criteria formulated in quantitative terms (indicators). The "facility of use" of an item of equipment, for example, can be measured (as a substitute) by the time required for the necessary organisational preparations (e.g. setting up). If this method cannot be used then an attempt must be made to describe the possible intensities of a criterion in words and to construct a scale on that basis. The outcome scale for the "availability" of maintenance staff, criterion, for example, could run like this: maintenance staff available, available after brief familiarisation, available only after fairly long familiarisation etc. As this example shows, criteria formulated in qualitative terms can still be made operational.

The partly numerical and partly verbal description of alternatives in terms of their criteria intensities can be summarized in a table called "an outcome matrix" (cf. Fig.3) This provides the data base for the next step in MCUA: the conversion of the outcomes into - initially unweighted - utility scores.

2.2.1.4. Partial evaluations of alternatives (= determination of utility scores)

A basic consideration is that, for complex alternatives evaluation cannot be effected via a single act of judgement. For this reason, in MCUA, the total evaluation problem is broken down in this way so that the decision-maker evaluates the single outcomes separately, i.e. he indicates, with regard to the individual criteria, what degree of goal attainment corresponds in his opinion to the intensities and what utility he attributes to these degrees of goal attainment. By assigning utility scores, the outcomes are converted into (unweighted) partial utilities through which at the same time the necessary conditions are created to permit the amalgamation of the outcomes measured in different dimensions.

For purposes of converting the criteria intensities into degrees of goal attainment and utility scores, a measurement scale (utility scale) has to be constructed. The first step in the construction of utility scales is to indicate for each individual criterion the intensities corresponding to 0 and 100 per cent goal attainment. The evaluator then has to divide up

according to his preferences, the range of criteria intensities In other words, he has to decide what intenstities within the intensity range of an outcome scale are - in his opinion - of equal utility and which are the intensities for which he feels there to be a difference in utility (3).

The sub division of the possible range of intensities into equivalent intervals gives a preference order from which a utility scale can be constructed directly.

By delimitation of intensity classes one arrives at utility scales at the ordinal level, i e. one can indicate whether utility differences are larger or smaller and one cannot indicate the quantity of the differences. It then depends on the ability of differentiation of the decision-maker as to whether the preferences with regard to the criteria intensities can be represented on utility scales of a higher "cardinal" level. If the decision-maker's preference structure is developed to the point that he is in a position to indicate utility differences in quantitative terms as a multiple of an arbitrarily determined unit of utility and if the zero point of the scale can be chosen at will, then the utility scores allotted to the intensities form a relative-equal interval scale. Conversely, if an empirically significant zero point can be established for the utility scale we have an absolute equal interval scale. Cardinal scales of this kind are the most informative and the only ones that allow unquestionable amalgamation of individual assessments into an overall judgement (for more details see Strebel, 1975).

A recapitulation of the types of scale that may, in principle, be used in outcome evaluation are set out in summary form in Table 2.

The utility scale is represented by numerical values assigned to the intensity classes in such a way that an increasing figure corresponds to increasing utility, in other words, the "best" intensity class is given the highest and the "worst" the smallest of the stipulated numerical values. In principle, various numerical orders may be used (e.g. 0, 1, 2. . . 0, 2, 4 . . . 0, 3, 6 . . .) For example, the intensity scales for the two criteria - "total annual costs"

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(3) The intensities of an outcome scale may be understood in psychometric terms as "stimuli" provoking a "reaction" from the evaluator in the form of a judgement. This judgement has to fall within the framework of a predetermined "reaction diagramme" (in our case a utility scale). The reaction of the evaluator therefore consists in deciding for one the alternative answers contained in the reaction diagramme (Sixtl, 1967)

The decision-maker's preference structure is such as to allow the following assessment of utility differences:	Evaluation at the highest possible scale level shown below is still significant:	
1. Identity and difference →	Nominal scale (e.g. colour scale)	
Plus 2. Direction of utility differences (greater/smaller) →	Ordinal scale (e.g. hardness scale)	
Plus 3. Quantitative assessment of utility differences as a multiple of an arbitrarily chosen utility unit →	Relative-equal interval scale (e.g. temperature scale)	Cardinal scale
Plus 4. Empirically significant determination of zero point of utility scale →	Absolute-equal interval scale (e.g. weight scale)	

Table 2. Significant types of scale in relation to the decision maker's preference structure.

and "liability to breakdown" could be given the sub-divisions shown in Table 3(a). The partial goal "acceptable cost" - is best attained by those alternatives for which total annual costs fall below $500. In the same way those alternatives show the highest degree of attainment - and therefore utility - for the partial goal "low liability to breakdown" whose intensity falls in the first intensity class. If, say, the utility scale shown in Table 3(b) has been stipulated, then the intensities in the first class are scored 4, those in the second are scored 3 and so on.

In connection with the construction of intensity classes the problem arises of how to determine the number and bredth of the intervals. Psychometric research has shown that, in view of the limits to human ability of differentiation, the maximum number of intensity classes per criterion that may be advocated is 9, but in practice, most evaluations are based on only 3 to 7 graduations (cf. e.g. Miller, 1967). The breadth of an intensity class is determined by the circumstances of each evaluation situation as well as the value system and subjective characteristics of the decision-maker - e.g. his level of aspiration.

(a)

Intensity class / Criterion	I	II	III	IV	V
Total annual cost (4)	<500	500 - <1000	1000 - <1500	1500 - <2000	≥2000
⋮	⋮	⋮	⋮	⋮	⋮
Liability to breakdown	much lower than normal	lower than normal	normal	higher than normal	much higher than normal
	↑	↑	↑	↑	↑
(b) Utility score	4	3	2	1	0
	very high utility (= very good)	high utility (= good)	average utility (= satis-factory	low utility (= ade-quate)	no utility (= unsat-isfactory

Table 3 : Example for the assignment of utility scores to equal value intensity classes

Occasionally, it may be difficult to fix the commencement and termination points of the intensity scales i.e. the respective minimum and maximum levels of the desired outcomes. In practice, this problem is frequently solved by establishing minimum and maximum levels by comparing the criteria intensities of the alternatives being considered, in other words ex post. Admittedly, this method is not exact since the starting and termination points of the scales ought to be determined independently of the observed outcomes of the alternatives investigated. However, in many situations there is no way of avoiding subsequent corrections to the limits originally set particularly if none of the alternatives reaches the minimum level. In this case, either new alternatives have to be found or else the level of aspiration has to be reduced i.e. a lower minimum level set. But, for practical reasons, too, it sometimes proves necessary to refer to the existing situation when determining scale starting and termination points. If it is found that the intensities for a criterion do not differ very much, then maximum and minimum levels on the intensity scales should not be too far apart; but, if the intensities are so close together that the decision-maker cannot attach different values to them, then the criterion concerned can be elimiated because it is of no relevance for the result of the evaluation.

In order to convert the outcomes into utility measures, one has to identify in which intensity interval the outcome falls. The score assigned to that interval represents the (unweighted) partial utility. Once all the outcomes are evaluated by the decision-maker in this way i.e. converted into utility scores, then there will be an order of preference among the alternatives for each criterion. The result of this first evaluation stage can be summarised in a "utility score matrix" (cf. Fig.3).

Parenthesis: evaluation by a group

The assumption that the evaluator or decision-maker is an individual is generally, in reality, incorrect. Most decisions - including the acquisition and use of media in schools - are taken by groups whose members may to some extent have differing preference structures. The literature offers various proposals for solving this problem in the context of evaluation and decision processes (cf. Dreyer, 1974). One suggestion is to reach prior agreement within the group on a value system that all the members accept as a compromise. Other authors propose that decision-makers should be allowed to assess only those aspects of a problem on which they are recognised experts. Another way of taking differences in competence among the decision-makers into account is to weight individual assessments in accordance with each person's capacity of judgement and specialised knowledge and then to aggregate these assessments into a group result. Other proposals include the aggregation of unweighted individual judgements and the use of Delphi techniques.

2.2.1.5. Weighting of criteria

Generally, it may be assumed that the decision-maker will differentiate between the importance of the criteria in terms of their contribution to global utility. The units selected for the individual utility scales will not therefore correspond and they will have to be weighted in order to be made comparable.

The weighting coefficients can be established by distributing 100 percentage points among the various criteria by direct assessment. This is, however, not practical if there is a very large number of criteria; in that case the answer is first of all to split the criteria into groups and give each group a weighting coefficient. The group weights obtained in this way can then be more easily distributed, in a second stage, among the individual criteria. If a structured catalogue of criteria in the form of a "goal system" is available then the criteria weights can be reached using the "successive comparison method". The goals at the lowest level of the hierarchy of the goal system are compared with each other in terms of their relevance for the attainment of the goal common to all of them at the level immediately above them. The relative importance of the sub-goals reached in this way can be expressed as fractions or percentages. Next, the weighting points assigned to the overall goal (generally 100) are split up among the goals at the individual levels of the hierarchy in accordance with their relevant importance.

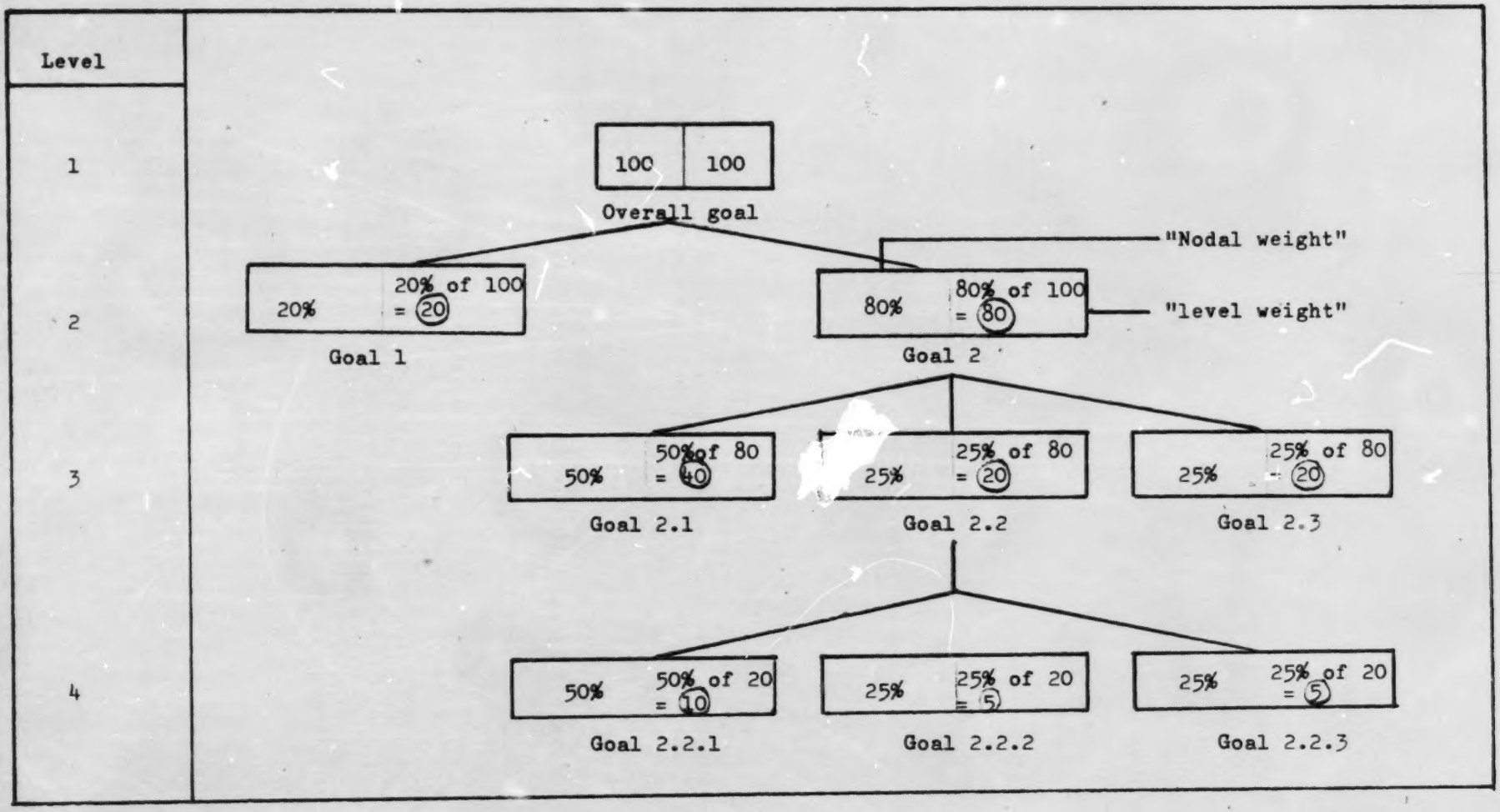
The method outlined for establishing criteria weights is shown in Figure 2. The figures shown to the left in each case represent the "nodal weight" i.e. the relative importance of a goal in relation to the goal at the level immediately above it. The encircled number on the right in each case is the "level weight" i.e. the relative weight of an element of the goal hierarchy in relation to the global goal.

The existence of goal dependance can also be taken into account in the weighting process (cf. also 2.2.1). Reasoning that the more a goal is supported indirectly by other goals the less direct support is necessary (and vice versa) a differentiated weighting of criteria is proposed. A "compatibility matrix" containing details of the nature and extent of relationships existing between the individual criteria can be used to determine the order in which the individual goals need direct support. On the basis of this ranking, the goal weights originally arrived at without taking goal dependence into account can be corrected (for details see Koelle, 1975).

2.2.1.6. Amalgamated index

In the next step, in order to arrive at an overall preference order of the alternatives, the partial utilities have to be amalgamated - taking into account the weights given

Fig.2. Determination of criteria weights



to the criteria by the decision-maker. The partial utilities established in this way then have to be amalgamated to a utility index for each alternative. Various rules have been worked out prescribing the method that has to be applied for utility amalgamation in a concrete case. The decisive factor as regards which rule should be used is the level of the utility scales, the position of their zero points and their cardinal comparability, i.e. the correspondence or non-correspondence between the individual scales regarding the number of intervals. An amalgamated index meeting the requirements of decision theory can be ensured if the decision-maker's preferences regarding criteria intensities can be represented on absolute-equal interval scales with corresponding zero points (4) or at least on relative-equal interval scales with cardinally comparable utility units (see reasons given by Strebel, 1975).

In real evaluation situations these strict conditions are not always met of course. For instance, it will often be possible to represent the preferences of the decision-maker with regard to criteria intensities only on utility scales at the ordinal level. Nor will it always be possible to have the same number of intervals for all criteria. The literature offers solutions for these situations as well in which theoretical exactitude is sacrificed in the interest of practicality.

The following table, 4, summarises the most important decision rules for utility amalgamation.

Decision rules for lower level scales can be used for higher level scales. If scales of different levels are used in evaluating outcomes the decision rule corresponding to the lowest level has to be used, but in this case the information offered by a scale above that level is lost. The object, therefore, should be to use the same level of scale throughout.

The result of the amalgamation process is an order of preference for the various alternatives taking all criteria into account ("utility index matrix" cf. Fig. 3). The higher the utility index of an alternative, the higher the rank; in other words, more the alternative is appropriate to attain the overall goal.

---

(4) This condition can be met by fixing desired limits for the individual criteria at the alternative preselection stage (see above). This sets a boundary between "unsatisfactory" intensities (utility = 0) and intensities described as "adequate and better" (utility > 0).

Type of scale

Ordinal scale	Rank addition rule:
	The utility index of an alternative is equal to the sum of the rankings given to it. If the units of the scales are disparate then the ranking scores have to be multiplied by the relevant criterion weight
Relative-equal interval scales	Additive weight rule
	The utility indes of an alternative is arrived at by adding together utility differences
(a) m utility scales with equal units	$U_h = \sum_{j=1}^{m} \sum_{i=1}^{n} (Unj - Uij)$
(b) m utility scales with unequal units	$U_h = \sum_{j=1}^{m} \sum_{i=1}^{n} Wj\ (Unj - Uij)$
Absolute-equal interval scales	Additive weighting rule
	The utility index of an alternative is arrived at by adding together utility scores
(a) m utility scales with equal units	$Uh = \sum_{j=1}^{m} Uhj$
(b) m utility scales with unequal units	$Uh = \sum_{j=1}^{m} Wj.\ u_{h_j}$
(c) m utility scales with unequal units cardinally non-comparable utility units	$Ui = \prod_{j=1}^{m} u_{ij}^{wj}$

Symbols : U_i : index for alternatives A_i, i = 1 . . . n

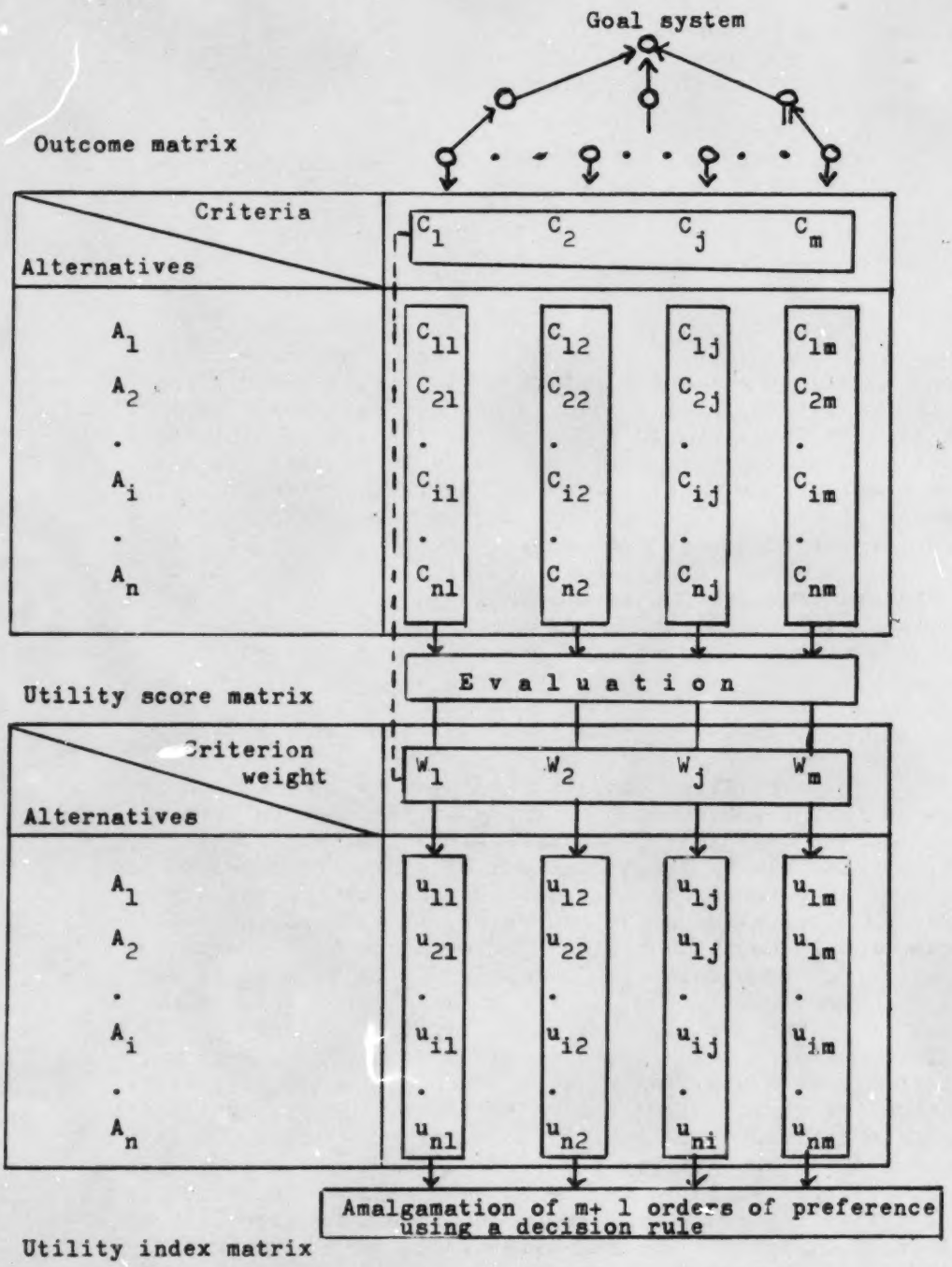
W_j : weighting coefficients for criteria Cj, j = 1 . . . m

U_{ij} : utilities of outcomes C_{ij}.

These decision rules apply to the determination of the utility index of alternatives A_h, h = 1 . . . n, $h \neq i$.

Table 4 : Main decision rules for utility amalgamation

Fig.3. Diagrammatic representation of Multi-Criteria Utility Analysis



Utility index matrix

Alternatives	Indices
A_1	U_1
A_2	U_2
.	.
A_i	U_i
.	.
A_n	U_n

In practice, costs often are dealt with separately for operational reasons and not included in the goal system beforehand as a goal dimension. In this case, the selection of alternatives is made by means of a utility cost quotient The alternative giving the highest quotient is the most advantageous.

The essential stages of MCUA are shown diagrammatically in Figure 3 from (Zangemeister, 1970).

2.2.1.7. Sensitivity analysis

Supplementing the method described above, sensitivity analysis can be used - this is recommended at least in wide-ranging evaluations - to pinpoint the effects on the result of changing single evaluation assumptions. Since the utility index is, to a decisive extent, determined by the relative importance attached by the decision-maker to the individual criteria, it is natural to think of checking the effects of different weightings on the evaluation result by a preference simulation process. The sensitivity of the result to a change in criteria intensities can also be investigated when forecasted quantities are involved to which some uncertainty attaches. Another test is to see how stable the result is if the criteria evaluation is changed.

2.2.2. Necessary conditions for the use of MCUA

The first condition to bear in mind when using MCUA is that the breakdown of the multi-dimensional evaluation problem into one-dimensional partial evaluations is, logically, only permissible if the assignment of a utility score on the basis of an outcome can be made independently of the other outcomes of an alternative. However, it is rare for the assumption of complete utility independence of criteria to apply in concrete selection situations. In general it may be taken that an alternative can be considered as a potential solution to the decision problem only if it offers certain minimum outcomes with regard to all - or at least most - criteria. When applying MCUA in practical cases, therefore, minimum and maximum limits have to be set for outcomes which the alternatives must not fall below or rise above. Within these limits, the utility independence assumption is permissible, in other words it may be assumed that the decision-maker will evaluate a criterion independently of the intensity of the other criteria. In real situations, therefore, only limited utility independence may be assumed.

The utility independence assumption implies that the total utility of an alternative is arrived at by an additive process from the partial utilities. A decision rule for amalgamating partial utilities, therefore, must always be an additive rule. Since, moreover, the amalgamation is based on the assumption that the criteria weights are constant, i.e. independent of the level of the utility scores or outcomes, then the overall utility function is a linear, monotonically increasing function of the partial utilities. The assumption

of a monotonically increasing overall utility function is plausible, though not formally demonstrable, and has been confirmed by experiment. Restriction to a linearly increasing overall utility function would not seem to have any serious repercussions primarily because the partial utilities can habe any kind of non-linear course (Zangmeister 1970). For practical evaluation purposes, this condition may therefore be disregarded.

A further important point is to ensure consistency concerning the preference structure, in other words, its independence of added or discarded alternatives. The point of this condition is to ensure that different preferences are not used by the decision maker in various evaluations which would mean that one alternative would have a different relative ranking in relation to the others. This condition can be met by having the evaluations made by an expert.

The last requirement to be taken into account is that of causal independence among the criteria. This aspect has already been dealt with in the paragraphs discussing the construction of a goal system (cf. 1.2.1.)

2.2.3. General appraisal of MCUA

The evaluation method that has been described is an effective aid to the solution of problems particularly in those decision situations - such as the selection of AV media - where many quantitative and qualitative aspects have to be taken into account. Compared with the more or less intuitive approach which generally prevails, in practice, in the selection of media, a decision-making process based on MCUA is more systematic, transparent and rational. On the basis of exactly-defined goals, all the alternatives to be considered for achieving these goals are subjected to thorough evaluation. The preferences and value judgements of the decision-maker are fully explicated and the way in which judgement has been reached can be reconstructed and verified by an outsider. If MCUA can be successfully used on a broad basis for media evaluation then the aggregate effect of the cost savings and/or increases in effectiveness achievable in this way could well lead to an appreciable improvement in internal efficiency in the whole education sector.

3. Example of the use of MCUA for evaluating AV media

Goal set in the example

Part 2 outlined the theoretical procedure for evaluating alternatives with the aid of MCUA. In section 1.2 the formulation of a goal system for this purpose was described in detail. The purpose of the following paragraphs is to demonstrate the practical stages of MCUA on the basis of these principles, with the aid of an example. According to the purpose of this example the basic problem is set in simplified terms, but the example itself deals with a concrete case of AV media evaluation

Problem

A training centre is confronted with the task of introducing a new course. The following requirements, in particular, are recognised to be important in the choice of media:

- the cost per addressee per hour must not exceed a prescribed maximum;
- there is also a maximum limit for the (real) acquisition cost;
- among other things, graphic representations and motion sequences have to be explained so that simultaneous presentation of sound and picture is necessary;
- the media system must be completed within six months.

The following media have to be examined as possible alternatives:

- teachers;
- books;
- AV media.

Stages in the MCUA method

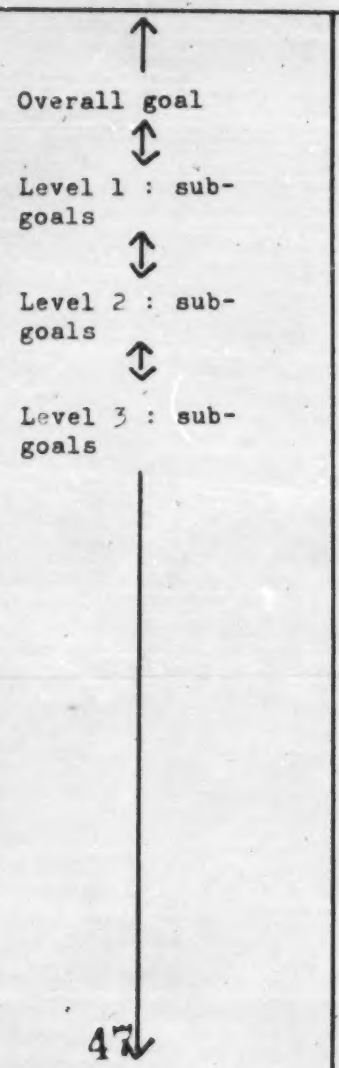
Stage	Action to be taken, with example
Stage 1 Construction of a goal system	- Breakdown of overall goal into sub-goals (end-means relationship) in such a way that the overall goal is attained if the sub-goals are attained - Operationalisation of sub-goals at the lowest level of the goal system o Dimension of goal attainment o Extent, time and time span of goal attainment - Check on goal compatibility Table 5, shows the goal system on which the example is based. Table 6 shows the results of the compatibility test. The following scores were used to indicate nature and extent of goal relationships + 3 : high goal harmony + 2 : medium goal harmony + 1 : low goal harmony 0 : goal neutrality - 1 : low goal competition - 2 : medium goal competition - 3 : high goal competition In the present example no cases of high goal competition arise and the goal system can therefore be kept as it is.

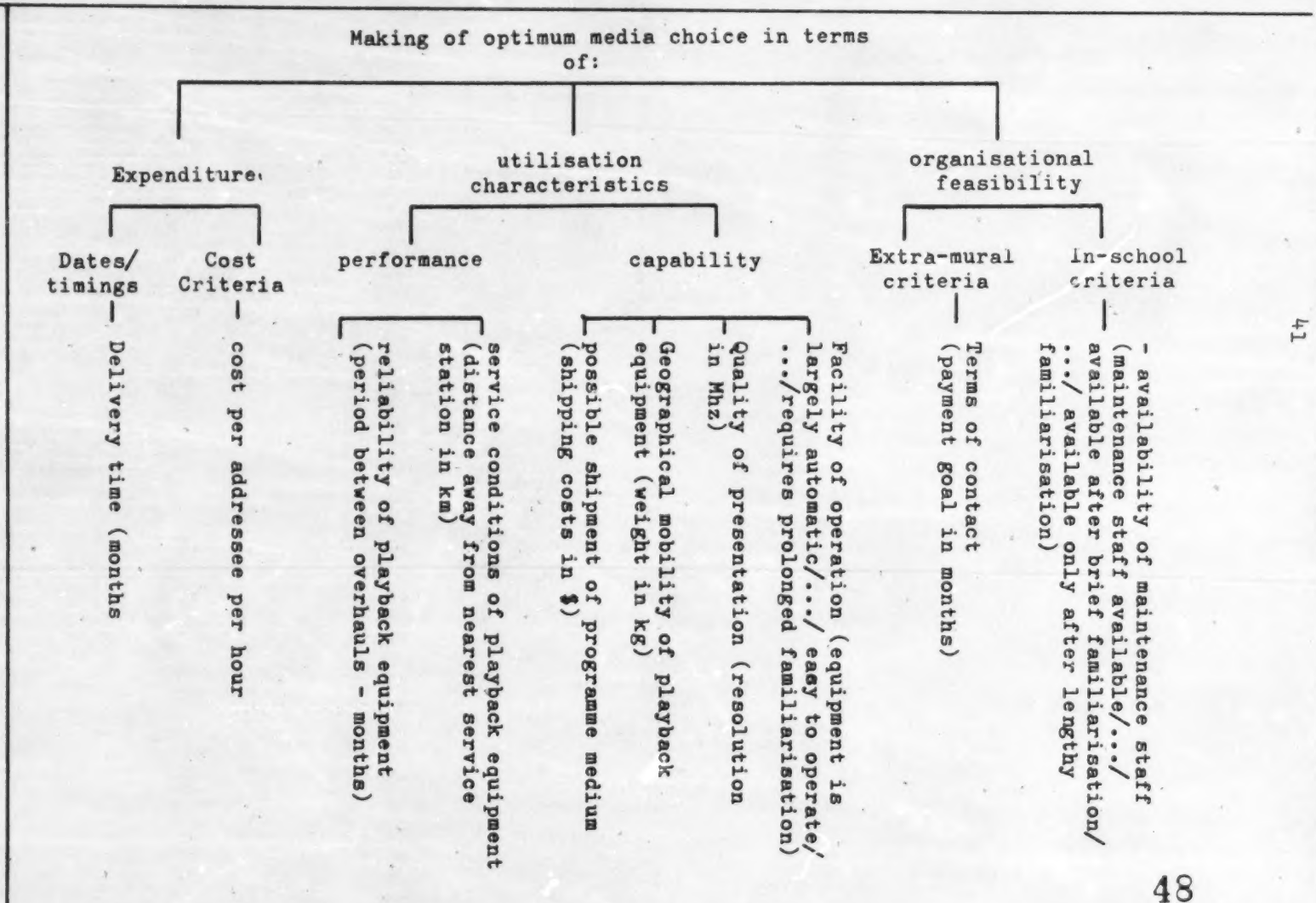
Stage 2 Pre-selection of alternatives	- Setting of minimum requirements The requirements listed in the statement of the problem regarding the need for simultaneous picture and sound and the representation of motion sequences rule out both teachers and books as possible media. Analysis shows that three different AV systems - A_1, u A_2, and A_3, meet all the conditions specified. All three alternatives are therefore regarded as at least adequate. For the further stages of MCUA, therefore, utility independence of criteria may therefore be assumed.
Stage 3 Description of alternatives in terms of their criteria intensities (determination of outcomes)	- Determination of outcomes for the sub goals at the lowest level of the goal system. Table 7 shows the outcome matrix for the present example. Each alternative A_1, A_2, A_3 is characterised by its specific criteria intensities.

Stage 4 Partial evaluations of alternatives (= scoring)	- Demarcation of possible range of criteria intensities (points at which the outcome scales begin and end) - Division of criteria intensity scale into equivalent intervals - Determination of the type of scale to suit the decision-maker's preference structure - Conversion of outcomes for each alternative into utility scores In this example it was decided to have a relative equal interval scale for alternative evaluation, in other words it was assumed that the decision maker would be in a position, apart from the information on identity and difference and the classification of utility intensities on the larger/smaller basis, to make quantitative judgements on utility differences. A scale with five intervals - 1, 2, 3, 4, 5 - is used for each goal criterion. The scale units are arbitrary but uniform for each criterion. The result of the evaluation is given in the utility score matrix shown in Table 9
Stage 5 Weighting of criteria	- Establishment of weights corresponding to the decision-maker's preference structure Table 8 sets out the "nodal weights" $W_{s,j}$ for the individual criteria arrived at by direct estimation (serial number j per goal level s) for the example considered. Criteria weights W_j for the overall goal are shown in the score matrix in Table 8 for the lowest level goal criteria

Stage 6 Amalgamation	- Amalgamation of utility scores using weighting coefficients and a decision rule to suit the situation (e.g. corresponding to level of scale utility zero point, etc) On the basis of Table 4 (Chapter 2.2.1.6) using a relative-equal interval scale, the the utility U_h for alternatives A_h ($h=1...3$; $h \neq i$) basing on scores u_{ij} and taking into account criteria weighting w_j - is $$U_h = \sum_{j=1}^{m} \sum_{i=1}^{n} w_j \, (u_{hj} - u_{ij})$$ In the present example, the amalgamation can be worked out from the score matrix shown in Table 9. For each sub-goal at the lowest level of the goal system, the respective weighting coefficient is shown in this table. Step-by-step corresponding to the chosen decision rule for amalgamation - the utility index is calculated for each alternative under consideration. On the basis of the criteria shown and their weighting, and the assumptions made, alternative A_2 is to b e preferred to alternative A_3 and the latter to alternative A_1 in the present example.

Table 5 Goal system for AV media evaluation (example) - see also table 1, page 11




Making of optimum media choice in terms of:
Expenditure
utilisation characteristics
organisational feasibility
Dates/ timings
Cost Criteria
performance
capability
Extra-mural criteria
In-school criteria
Delivery time (months
cost per addressee per hour
service conditions of playback equipment (distance away from nearest service station in km)
reliability of playback equipment (period between overhauls - months)
possible shipment of programme medium (shipping costs in $)
Geographical mobility of playback equipment (weight in kg)
Quality of presentation (resolution in Mhz)
Facility of operation (equipment is largely automatic/.../ easy to operate/ .../requires prolonged familiarisation)
Terms of contact (payment goal in months)
- availability of maintenance staff (maintenance staff available/.../ available after brief familiarisation/ .../ available only after lengthy familiarisation)

increasing attainment with regard to goal criteria C_j, j = 1. . . 10 of the lowest goal level. / Effect on criteria C_j, j = 1. . . 10 of the lowest goal level	1. Shortening of delivery time	2. Lowering of cost per addressee per hour	3. Increase in reliability of playback equipment	4. Improvement in service conditions for playback equipment	5. Improvement in shipment possibilities of programme medium	6. Improvement in geographical mobility of playback equipment	7. Improvement in quality of presentation	8. Improvement in facility of operation	9. Improvement in terms of contract	10. Improvement in availability of maintenance mstaff
1. Shortening of delivery time	-	o	o	o	o	o	o	o	o	o
2. Lowering of cost per addresee per hour	-1	-	+2	+2	+1	+1	-1	+1	+2	-1
3. Increase in reliability of playback equipment	o	-1	-	+2	o	-1	o	+1	0	+2
4. Improvement in service conditions for playback equipment	o	o	o	-	o	o	o	o	o	+2
5. Improvement in shipment possibilities of programme medium	o	o	o	o	-	o	o	o	o	o
6. Improvement in geographical mobility of playback equipment	o	o	+1	-1	o	-	o	o	o	o
7. Improvement in quality of presentation	o	-2	o	o	o	o	-	o	o	o
8. Improvement in facility of operation	o	-1	o	o	o	o	o	-	o	o
9. Improvement in terms of contract	o	o	o	o	o	o	o	o	-	o
10. Improvement in availability of maintenance staff	-1	o	o	o	o	o	o	o	o	-

Example: increasing attainment of goal criteria 3 (increase in reliability of playback equipment) is in medium goal harmony with goal criteria 2 (lowering of cost per addressee per hour)

Table 6 - Compatibility matrix

Table 5 Goal system for AV media evaluation (example) - see also table 1, page 11

Overall goal
Level 1 : sub-goals
Level 2 : sub-goals
Level 3 : sub-goals
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Making of optimum media choice in terms of:
Expenditure
utilisation characteristics
organisational feasibility
Dates/ timings
Cost Criteria
performance
capability
Extra-mural criteria
In-school criteria
Delivery time (months
cost per addressee per hour
service conditions of playback equipment (distance away from nearest service station in km)
reliability of playback equipment (period between overhauls - months)
possible shipment of programme medium (shipping costs in $)
Geographical mobility of playback equipment (weight in kg)
Quality of presentation (resolution in Mhz)
Facility of operation (equipment is largely automatic/.../ easy to operate/ .../requires prolonged familiarisation)
Terms of contact (payment goal in months)
- availability of maintenance staff (maintenance staff available/.../ available after brief familiarisation/ .../ available only after lengthy familiarisation)
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1. Shortening of delivery time	2. Lowering of cost per addressee per hour	3. Increase in reliability of playback equipment	4. Improvement in service conditions for playback equipment	5. Improvement in shipment possibilities of programme medium	6. Improvement in geographical mobility of playback equipment	7. Improvement in quality of presentation	8. Improvement in facility of operation	9. Improvement in terms of contract	10. Improvement in availability of maintenance mstaff	increasing attainment with regard to goal criteria C_j, j = 1. . . 1o of the lowest goal level. / Effect on criteria C_j, j = 1. . . 10 of the lowest goal level
-	o	o o	o	o	o o	o	o	o	1. Shortening of delivery time
-1	-	+2+2	+1	+1	-1	+1	+2	-1	2. Lowering of cost per addresee per hour
o	-1	-+2	o	-1	o	+1	0	+2	3. Increase in reliability of playback equipment
o	o	o -	o	o	o	o	o	+2	4. Improvement in service conditions for playback equipment
o	o	o o	-	o	o	o	o	o	5. Improvement in shipment possibilities of programme medium
o	o	+1-1	o	-	o	o	o	o	6. Improvement in geographical mobility of playback equipment
o	-2	o o	o	o	-	o	o	o	7. Improvement in quality of presentation
o	-1	o o	o	o	o	-	o	o	8. Improvement in facility of operation
o	o	o o	o	o	o	o	-	o	9. Improvement in terms of contract
-1	o	o o	o	o	o	o	o	-	10. Improvement in availability of maintenance staff

Example: increasing attainment of goal criteria 3 (increase in reliability of playback equipment) is in medium goal harmony with goal criteria 2 (lowering of cost per addressee per hour)

Table 6 - Compatibility matrix

Criteria C_j, j=1...10 of the ^{j} lowest goal level.	Alternatives A_i, i = 1...10		
	A_1	A_2	A_3
1. Delivery time (months)	3	2	2
2. Cost per addressee per hour ($ per addresee per hour)	20	10	15
3. Reliability of playback equipment (period between overhauls - months)	4	4	3
4. Service conditions for playback equipment (distance away from nearest service state in km)	3	0	0
5. Possible shipment of programme medium (shipping costs in $)	5	2	3
6. Geographical mobility of playback equipment (weight in kg)	25	20	15
7. Quality of presentation (resolution in Mhz)	4	35	3
8. Facility of operation (equipment is largely automatic/.../easy to operate /.../ requires prolonged familiarisation)	... prolonged familiarisation	largely automatic	easy to operate
9. Terms of contract (payment goal in months)	3	0	0
10. Availability of maintenance staff (maintenance staff available/.../available after brief familiarisation /.../available only after lengthy familarisation)	... long familiarisation	is available	is available

Table 7 : outcome matrix

Level of goal system s = 1...4	Goal criteria no. j per goal level s	Nodal weights	
		$W_{s,j}$	Total
1	1 Making of optimum media selection	100	100
2	1 Expenditure	40	
	2 Characteristics of utilisation	40	
	3 Organisational feasibility	20	100
3	1 Dates/timings	30	
	2 Cost criteria	70	100
	3 Performance	50	
	4 Capacity	50	100
	5 Extra-mural criteria	50	
	6 In-school criteria	50	100
4	1 Delivery time	100	100
	2 Cost per addressee per hour	100	100
	3 Reliability of playback equipment	50	
	4 Service conditions for playback equipment	50	100
	5 Possibilities of shipping the programme medium	10	
	6 Geographical mobility of playback equipment	10	
	7 Quality of presentation	40	
	8 Facility of use	40	100
	9 Terms of contract	100	100
	10 Availability of maintenance staff	100	100

Example: The overall goal criteria No.1. on level 1 ("Making of optimum media selection") with a "nodal weight" of W11 = 100 is composed by three sub-goals (expenditure, characteristics of utilisation and organisational feasibility) on goal level 2 in a ratio of W21/W22/W23 = 40/40/20. Goal no. 2. in goal level 2 (expenditure) is composed by the first two sub-goals (Dates/timings and cost criteria) on goal level 3 in a ratio of W31/W32 = 30/70

Table 8 "Nodal weights for goal criteria"

Goal criteria C_j lowest goal level, j = 1...10	weighting co-efficient w_j	utility scores u_{ij}			$\sum_{i=1}^{3}(u_{hj} - u_{ij})$			$\sum_{i=1}^{3} w_j (u_{hj} - u_{ij})$			$u_h = \sum_{j=1}^{10}\sum_{i=1}^{3} (u_{hj}-u_{ij})$		
		A_1	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3
1. Delivery time	0.12	1	3	3	-4	+2	+2	-0.48	0.24	0.24			
2. Cost per addressee per hour	0.28	1	5	3	-6	+6	0	-1.68	1.68	0			
3. Reliability of playback equipment	0.10	4	4	3	+1	+1	-2	0.10	0.10	-0.20	-3.14		
4. Service conditions of playback equipment	0.10	3	5	5	-4	+2	+2	-0.40	0.20	0.20			
5. Shipment possibility of programme medium	0.02	1	4	3	-5	+4	+1	-0.10	0.08	0.02			
6. Geographical mobility of playback equipment	0.02	1	3	4	-5	+1	+4	-0.10	0.02	0.08		2.92	
7. Quality of presentation	0.08	5	3	2	+5	-1	-4	0.40	-0.08	-0.32			0.22
8. Facility of operation	0.08	1	5	3	-6	+6	0	-0.48	0.48	0			
9 Terms of contract	0.10	3	1	1	+4	-2	-2	0.40	-0.20	-0.20			
10. Availability of maintenance staff	0.10	1	5	5	-8	+4	+4	-0.80	0.40	0.40			

Table 9 Utility score matrix

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Glossary

- criteria, goal~, evaluation~: Synonym terms for an operationally defined goal.
- criterion (goal) weight : indicates the importance the decision-maker attaches to a criterion in terms of its contribution to → global utility of a measure, project, etc.
- compatibility matrix :

  contains for each → evaluation criteria particulars of the nature and extent of (horizontal) relationships existing to other criteria. With regard to the nature of the relationships a distinction can be made between
  - complementarity: as the degree of attainment of one criterion increases so does that of another;
  - neutrality: the attainment of one criterion has no effect on that of another;
  - incompatibility: as the degree of attainment of one criterion increases, that of another decreases.
- Evaluation methods for the comparison of alternatives :
  - Cost-benefit analysis (CBA): By this method planned projects are evaluated and selected on the basis of their net benefit to the economy as a whole. For this purpose the expected effects of the project are established for a given period of time and - through evaluation in monetary units - converted into "social" costs and benefits made comparable by discounting to a common point in time.
  - Cost-effectiveness analysis (CEA): Here the monetary resource input of a project, i.e. its costs, are compared

.../.

with the project outcomes, measured in different non-monetary units. An essential characteristic of CEA is that there is no explicit synthesis of the incommensurate outcomes to an index of the overall worth of an alternative, which would generally require a conversion to a standard dimension (monetary units, → utility); in other words the amalgamation of the different outcomes is made implicitly by the decision-maker.

- Multi-criteria utility analysis (MCUA): MCUA is a method for evaluating alternatives (projects, programmes, etc.) in complex decision situations. It allows a fully explicated evaluation of alternatives taking into account not only a multi-dimensional goal system but also the relative importance of the individual goals and outcomes for the decision-maker (i.e. his preference structure). The evaluation process takes place in two stages: Firstly the incommensurate outcomes (intensities) of an alternative are given the same denominator by assigning utility scores which indicate the individual preference of the decision-maker regarding the outcomes. To put the alternatives in order of preferability, the individual utility scores are then combined into an overall score (utility index) for each alternative taking into account the relative importance (i.e. the → weights) given to the criteria by the decision-maker.

- Utility: the subjective value of a measure, project, etc., determined by its usefulness for goal attainment.
- Sensitivity analysis: method that allows investigation of effects of parameter variations on the evaluation result.

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